

Claims

We claim:

1. A micromirror device comprising:

a reflecting element that can be deflected into at least 2 states; and

a support structure for supporting said reflecting element, said support structure comprising at least 1 wall.

2. The device of claim 1, wherein said reflecting element comprises at least 1 metallic layer.

3. The device of claim 1, wherein said reflecting element comprises at least 1 semiconductor layer.

4. The device of claim 1, wherein said reflecting element comprises a plurality of dielectric layers.

5. The device of claim 1, wherein the reflective surface of said reflecting element is substantially planar with neither depressions nor protrusions.

6. The device of claim 1, wherein the reflective surface of said reflecting element has no outer edges that are perpendicular to the projection of the incident light propagation vector onto the plane of said reflective surface.

7. The device of claim 1, wherein said at least 1 wall is oriented such that the angle between the projection of the incident light propagation vector onto the plane of the reflective surface of said reflecting element and a wall segment of said at least 1 wall is between 0° and 75°.

8. The device of claim 1, wherein said angle is between 0° and 60°.

9. The device of claim 1, wherein said angle is between 0° and 45°.

10. The device of claim 1, wherein said at least 1 wall is contained in a layer that is separate from the layer that contains said reflecting element.
11. The device of claim 1, wherein said support structure comprising at least 1 wall comprises a material selected from the group consisting of: polycrystalline silicon, monocrystalline silicon, amorphous silicon, Al, Al alloy, Mo, W, TiSi_2 , WSi_2 , CoSi_2 , Ti:W, TiN, and Cu.
12. The device of claim 11, wherein said polycrystalline silicon is doped.
13. The device of claim 11, wherein said monocrystalline silicon is doped.
14. A micromirror device comprising:
 - a reflecting element that can be deflected into at least 2 states;
 - a support structure for supporting said reflecting element, said support structure comprising at least 1 wall; and
 - a deformable element that is connected to said support structure.
15. The device of claim 14, wherein said deformable element is a torsion hinge.
16. The device of claim 14, wherein said deformable element comprises a crystalline semiconductor material.
17. The device of claim 16, wherein said crystalline semiconductor material is selected from the group consisting of polycrystalline silicon and monocrystalline silicon.
18. The device of claim 16, wherein said crystalline semiconductor material is doped.
19. A micromirror device comprising:
 - a reflecting element that can be deflected into at least 2 states;

a 1st support structure for supporting said reflecting element, said support structure comprising at least 1 wall;
a torsion hinge that is connected to said 1st support structure; and
a 2nd set of support structures for supporting said torsion hinge, said 2nd set of support structures defining an axis of rotation of said torsion hinge.

20. The device of claim 19, wherein each of said 2nd set of support structures comprises at least 1 portion for limiting the deflection of said reflecting element.

21. The device of claim 19, wherein said 2nd set of support structures comprises support structures selected from the group consisting of: triangular structures, polygonal structures, walls, elliptical structures, and circular structures.

22. The device of claim 19, wherein said 2nd set of support structures comprises a material selected from the group consisting of: polycrystalline silicon, monocrystalline silicon, amorphous silicon, Al, Al alloy, Mo, W, TiSi_2 , WSi_2 , CoSi_2 , Ti:W, TiN, and Cu.

23. The device of claim 22, wherein said polycrystalline silicon is doped.

24. The device of claim 22, wherein said monocrystalline silicon is doped.

25. The device of claim 19, wherein said torsion hinge comprises a crystalline semiconductor material.

26. The device of claim 25, wherein said crystalline semiconductor material is selected from the group consisting of polycrystalline silicon and monocrystalline silicon.

27. The device of claim 25, wherein said crystalline semiconductor material is doped.

28. A micromirror device comprising:

a reflecting element that can be deflected into at least 2 states;

a 1st support structure for supporting said reflecting element, said support structure comprising at least 1 wall;

a deformable element that is connected to said 1st support structure;

a 2nd set of support structures for supporting said deformable element; and

a base layer for supporting said 2nd set of support structures, said base layer having a 1st surface and a 2nd surface, with said 1st surface facing said reflecting element.

29. The micromirror device of claim 28, wherein said base layer comprises a crystalline semiconductor material.

30. The micromirror device of claim 29, wherein said crystalline semiconductor material is selected from the group consisting of polycrystalline silicon and monocrystalline silicon.

31. The device of claim 28, wherein said base layer additionally comprises addressing electrodes for actuating said reflecting element.

32. The device of claim 28, wherein said base layer additionally comprises addressing electrodes for actuating said deformable element.

33. The device of claim 28, wherein said base layer additionally comprises control circuitry.

34. The device of claim 33, wherein said control circuitry is disposed on said 1st surface of said base layer.

35. The device of claim 33, wherein said control circuitry is disposed on said 2nd surface of said base layer.

36. The device of claim 33, wherein said control circuitry is selected from the group consisting of: CMOS circuits, NMOS circuits, PMOS circuits, bipolar transistor circuits, BiCMOS circuits, DMOS circuits, HEMT circuits, amorphous silicon thin film transistor circuits, polysilicon thin film transistor circuits, SiGe transistor circuits, SiC transistor circuits, GaN transistor circuits, GaAs transistor circuits, InP transistor circuits, CdSe transistor circuits, organic transistor circuits, and conjugated polymer transistor circuits.

37. A method of fabricating a micromirror device, comprising the steps of:
providing a 3-layer substrate, comprising a 1st bottom layer, a 2nd intermediate layer, and a 3rd top layer;
patterning said 3rd top layer to form a deformable element;
forming a 1st set of support structures for said deformable element;
removing at least a portion of said 2nd intermediate layer to form a gap between said deformable element and said 1st layer;
forming a 2nd support structure comprising at least 1 wall on said deformable element;
depositing at least 1 reflecting layer, such that it is supported by said 2nd support structure comprising at least 1 wall; and
patterning said at least 1 reflecting layer to form a reflecting element.

38. The method of claim 37, wherein said 3-layer substrate is a silicon-on-insulator (SOI) substrate and said 1st bottom layer is a handle wafer, said 2nd

intermediate layer is a buried silicon oxide layer, and said 3rd top layer is a silicon layer.

39. The method of claim 38, wherein said 3rd top layer is an epitaxial silicon layer.

40. The method of claim 37, wherein said 1st set of support structures for said deformable element comprises a material selected from the group of consisting of: polycrystalline silicon, monocrystalline silicon, amorphous silicon, Al, Al alloy, Mo, W, TiSi_2 , WSi_2 , CoSi_2 , Ti:W, TiN, and Cu.

41. The method of claim 40, wherein said polycrystalline silicon is doped.

42. The method of claim 40, wherein said monocrystalline silicon is doped.

43. The method of claim 37, wherein said deformable element comprises a crystalline semiconductor material.

44. The method of claim 43, wherein said crystalline semiconductor material is selected from the group consisting of polycrystalline silicon and monocrystalline silicon.

45. The method of claim 43, wherein said crystalline semiconductor material is doped.

46. The method of claim 37, wherein said deformable element is a torsion hinge.

47. The method of claim 37, wherein said 2nd support structure for said reflecting element comprises a material selected from the group of consisting of: polycrystalline silicon, monocrystalline silicon, amorphous silicon, Al, Al alloy, Mo, W, TiSi_2 , WSi_2 , CoSi_2 , Ti:W, TiN, and Cu.

48. The method of claim 47, wherein said polycrystalline silicon is doped.

49. The method of claim 47, wherein said monocrystalline silicon is doped.

50. The method of claim 37, wherein said at least 1 reflecting layer comprises at least 1 metallic layer.
51. The method of claim 37, wherein said at least 1 reflecting layer comprises at least 1 semiconductor layer.
52. The method of claim 37, wherein said at least 1 reflecting layer comprises a plurality of dielectric layers.
53. The method of claim 37, additionally comprising the step of providing a substantially planar surface for the deposition of said at least 1 reflecting layer.
54. The method of claim 37, additionally comprising the step of planarizing the reflecting surface of said reflecting element.
55. The method of claim 54, wherein said step of planarization comprises a chemical mechanical polishing (CMP) step.
56. The method of claim 37, additionally comprising the step of planarizing the reflecting surface of said at least 1 reflecting layer.
57. The method of claim 56, wherein said step of planarization comprises a chemical mechanical polishing (CMP) step.
58. The method of claim 37, additionally comprising the step of forming at least 1 addressing electrode.
59. The method of claim 37, additionally comprising the step of forming control circuitry.
60. The method of claim 59, wherein said control circuitry is formed on said 1st bottom layer.

61. The method of claim 59, wherein said step of forming control circuitry comprises a step of fabricating circuits selected from the group consisting of: CMOS circuits, NMOS circuits, PMOS circuits, bipolar transistor circuits, BiCMOS circuits, DMOS circuits, HEMT circuits, amorphous silicon thin film transistor circuits, polysilicon thin film transistor circuits, SiGe transistor circuits, SiC transistor circuits, GaN transistor circuits, GaAs transistor circuits, InP transistor circuits, CdSe transistor circuits, organic transistor circuits, and conjugated polymer transistor circuits.